Food Security and Biotechnology in Africa

This project is financed by the European Union
and implemented by the ACP Secretariat

MODULE 3
PUBLIC RESPONSE TO THE RISE OF BIOTECHNOLOGY

Prof. Nnadi Ajanwachukwu
University of Nigeria, Nsukka

Module contents

- Unit 1: Introduction to biotechnology
- Unit 2: Public. Who constitutes the public and how do they respond to the rise in biotechnology
- **Unit 3: Benefits and risks of biotechnology**.
- Unit 4: Biotechnology and African agriculture
- Unit 5: Dealing with public response in the context of African agriculture

Final version, February 2017

Disclaimer
This publication has been produced with the assistance of the European Union. The contents of this publication is the sole responsibility of the author and can in no way be taken to reflect the views of the European Union.

UNIT 3:
Benefits and risks of biotechnology.
(6 Hours)

Prof. Nnadi Ajanwachukwu
University of Nigeria, Nsukka

Objectives:

- Introduce the concept of biotechnology
- Discuss the potential contributions of Biotechnology to sustainable agricultural productivity, food security, medicine and the environment.
- Highlight the potential risks of the technology
- Take a middle of the way course to emphasize the potential benefits of integrating biotechnology into agricultural systems.

Introduction: Biotechnology, agriculture, human health and the environment.

- Upon coming to market in the early 1990s, agro-biotechnology promised dramatic benefits to farmers.
- Following this was a rapid adoption of Roundup-Ready Soybean and Bt corn signifying benefits to farmers.
- Hitherto, concerns have been high on how to feed the increasing world population in the face of dwindling natural resource base for agro-production.

Biotechnology, agriculture human health and environment.

- This follows the dwindling farm output, post green revolution that was powered by yield enhancing technologies.
- A testimony to the unsustainable nature of the green revolution as an agricultural system.
- The sustainable agro-perspective takes into account the limitations of high input options with focus on agro-ecology and farming systems.

Biotechnology, agriculture human health and environment.

- Moreover, the nutritionist and health practitioners are interested in the range of nutritional inputs rather than aggregate yield or production.
- Also, the agro-food industries with considerations for access, entitlements and livelihoods show less interest on output.
- Current emphasis on food is focused on social, economic, political and institutional factors that enhance or impede access to food.

Biotechnology, agriculture human health and environment

- According to FAO (2000), about 800 million people are estimated to be food insecure.
- Food insecurity and poverty are increasingly concentrated in Africa and South East Asia.
- It is agreed that Africa is the region least capable of dealing with the consequences of declining yields and increasing food prices.
- World population is projected to 8 billion people by 2020 with 6700million in the developing countries.

Biotechnology, agriculture human health and environment

- The region is also most vulnerable to the potential consequences of climate change on agro-production.
- According to Conway (1999), by 2020, there will be an extra 2billion people to feed.
- Biotechnology is going to be essential partner if yield ceilings are to be raised and-
- If crops are to be raised without excessive dependence on pesticides .

Biotechnology, agriculture human health and environment

- If farmers on less farmlands are to be provided with crops that are resistant to droughts and salinity.
- Use crops that can more efficiently make use of nitrogen and other nutrients.
- According to Prakash, recombinant DNA techniques constitute powerful and safe means for the modification of organisms and can contribute to improved agriculture, health, and environment.

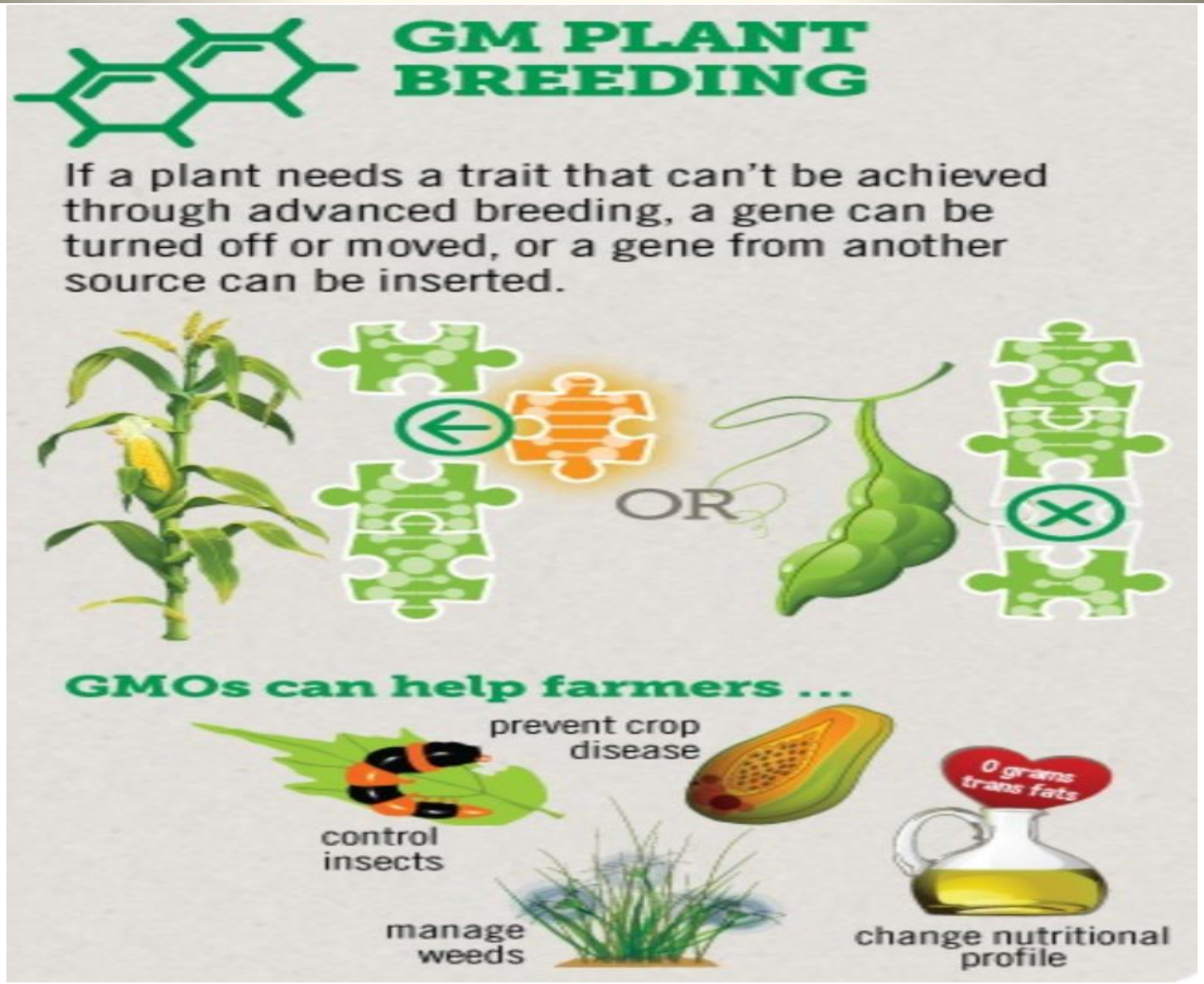
Biotechnology, agriculture human health and environment

- Furthermore, the science is neither new nor necessarily more dangerous than conventional ones.
- Does not pose new or heightened risks relative to improvements by conventional means.
- Offers greater flexibility and precision in application.
- Has the potential to address environmental challenges, hunger and poverty by improving productivity and greater nutritional security.

Benefits of Biotechnology

- Critical review of biotechnology debate will reveal demographic implications.
- Does the technology offer any benefit to consumers?
  - herbicide tolerance?
  - pest resistance?
- Does the technology benefit only the multinational conglomerates involved in the technology innovation and research?

Overview of some of the benefits.



Benefits to socioeconomic groups.

- Benefits of biotechnology are categorized based on socioeconomic groups as follows;
  - Farmers to whom improved yield reduced herbicide use will translate to financial gains.
  - Pesticide applicators to whom reduced pesticide application will translate to reduced exposure and intoxication
  - Chemical manufacturers and funders of GM technology who it is claimed reap the financial benefits.

Benefits to socioeconomic groups

- Improved shelf-life of products is of immense benefit to farmers, grocery stores.
- Improved nutritional quality of products is consumer specific benefit.

Environmental benefits.

- The two outstanding issues concerning adoption and use of biotechnology relate to
  - the potential effects on human health
  - the environment.
- In a way, development of pest resistance using biotechnology tools developed as a response to limitations of chemical pesticides on human and environmental health.
- But then, how does transgenesis for pest resistance benefit the environment?

Environmental benefits.

- The development of herbicide resistance /tolerance crops connotes specificity of herbicides to be used on crops.
- This also translates to reduction in reliance of agriculture to chemical applications.
- Biopesticides from genetic engineering within plants are more environmentally friendly and selective than chemical pesticides.

Environmental benefits cont.

- The use of biotechnology for pest control in agriculture will eliminate groundwater pollution associated with organic pesticides.
- Elimination of dangerous and expensive chemical inputs in agriculture.
- Reduction to elimination of chemicals that adversely affect biodiversity.
- Reduce the use of artificial fertilizers with its environmental effects as GE plants will more efficiently use atmospheric nitrogen.

Environmental benefits contd.

- Reduced environmental impact of pesticide use.
  - In 1998, 8.2million fewer pounds of active pesticide ingredients were used on corn, cotton and soybean than in 1997.
  - 2.5 million pounds decrease was specifically due to farmer's adoption of GE crops.
- Soil conservation .
  - Herbicide tolerant crops have proved beneficial to the environment by facilitating a shift to conservation tillage practices.
- Phytoremediation.
  - Genetic modification of plants or even micro-organisms may provide in situ remediation of polluted soil, sediments, surface waters and aquifers

Environmental benefits contd.

- Reduced vulnerability of crops to environmental stressors.
- GE crops resistant to drought and salinity which are limiting factors to productivity will provide protective and favourable sustainable ecosystem.
- GE forest trees resistant to diseases will improve their productivity, tree population and potentially will impact on the level of deforestation and biodiversity/habitat loss.

Food security and medical Benefits

- Increases in crop yields have been one of the leading drive for adoption of the innovation.
- Arising from crop pest control, this will impact greatly in improved food availability and security.
- Improved food quality via nutrient bio-fortification (iron, vit A, in crops) will compliment food security and improved health among the populations.

Benefits contd.

- Delayed ripening of fruits will enhance availability by reducing spoilage, and increase farmers profit.
- Production of bio vaccines & pharmaceuticals are of great benefit to human & animal health.
- In animal production GE has been used in the provision of forage species with improved yield or nutrient content for livestock.

Benefits of contd.

- Utilization of microorganisms to produce food additives.
- Production of hormones and hormone analogues for therapeutic purposes.
- Other benefits include sex selection, nuclear transfer, cloning livestock transgenics among others.
- There are also industrial applications of the technology beyond the mandate of this course.

Benefits of GM technology

Table 1 Potential Benefits from Plant Genetic Engineering

Benefit	Example
Increasing crop productivity	• Improving growth rate • Altering ratio of usable product (e.g., increased proportion of seed in rice plants)
Increasing crop quality	• Improving nutritional quality (e.g., specific vitamin contents, type and content of fiber, fat components, amino acids) • Removing food contaminants and toxins (e.g., aflatoxins) • Improving storage properties (e.g., fresh vegetables and fruits)
Environmental adaptation	• Making crops plants better adapted to changing environments
Broadening stress tolerance	• Making plants more resistant to drought, flooding, salinity, heavy metals, pollution
Increasing disease and pest resistance	• Selecting resistant varieties (e.g., using molecular techniques to insert antiviral or antibacterial genes from other species) • Hybridizing crops with wild relatives (e.g., use of cellular methods for rapid screening for desired phenotypes)
Agrochemical reduction	• Breeding crop varieties resistant to specific herbicides (e.g., glyphosate-resistant soybean, through insertion of a bacterial gene that reduces sensitivity to herbicide)
Production of nonedible substances	• Use of food crops to produce nonedible products (e.g., medicinal products and proteins, fuel alcohol, industrial oils) • Using food crops for polymer and bioplastic production
Use of new raw materials	• Production of single cell (e.g., growing bacteria on methanol for animal feed, growing mycoprotein from fungi and wastes from pulp and paper industry)

Source: Macer (1997).

Are there risks associated with adoption and use of biotechnology?

- Uncertainty is both a process and outcome in a bid to produce scientific knowledge &innovation.
- Also, a hallmark of scientific enterprise is its explicit acknowledgement of the possibility of gaps and incompleteness of what is known.
- Furthermore, equally appreciated is the fallibility of scientific theories and experiments.
  - These certainly apply to such major technology as biotechnology is!

How risky is biotechnology?

- Most biotechnology based solutions to agriculture are delivered in the form of new plants or strains of livestock.
- However, consumer concerns regarding some unclarified properties of the technology; regarding equity, environment , ethics & human health pose threats to its adoption and use.
- Certain issues need clarification and include;

Biotechnology; Doubts and Concerns

- Do biotechnology/GM food and food products pose unique hazard to human health?
- Are risks of biotechnology foods peculiar?
- Are there means of assessing the risks of GM organisms?
- Concerns and controversy about the risks to human and environmental health, ethics and equity over the innovation persist and these are stifling seamless adoption & use of the technology.

GMOs, What is known?

- There is no evidence that unique hazards exists either in the use of GE or in the transfer of genes between unrelated organisms.
- The risks associated with introduction of GE are the same with those associated with introduction of unmodified organisms or those modified by other techniques.
- Assessment of the risk of introducing GE organism into an environment should be
  - based on the nature of the organism;
  - the environment into which its being introduced.
- The method of modification is not significant.

Risks of GMOs

- Plants are the bedrock of human diets and presentation of transgenic crops as affecting human health arouse concern.
- Also, when human health is an issue, utilitarianism gets suspended.
- When human health is an issue, cost effective analysis cease to be useful.
  - These considerations have the capacity to crowd out the rationality of science

Biotechnology; Human health risks

- Potential human health risks of crop genetic modification fall into four broad categories;
  - Toxicity. This could occur as a result of the transgene elaborating proteins that are toxic to man. There was also an alleged case of toxic reactions to Bt maize pollen among humans in the Philippines

Perceived Risks

Table 2: Summary of Perceived and Genuine Risks of Genetically Engineered Foods and Crops

Nature of Risk	Type of Risk	Remarks
Food Safety	1. Toxins and poison. In 1998, a scientist in the Rowett Institute found that GE potatoes spliced with DNA from the snowdrop plant (a viral promoter) are poisonous to mammals.	The UK Government's Advisory Committee for Novel Food and Process examined the data and concluded that the experiment was faulty and the conclusions were wrong.
	2. Increased cancer risks. Monsanto's bovine somatotrophin (growth hormone) injected into dairy cows to produce more milk has been reported to cause cancer in human breast, prostate, and colon.	This is not a GM food. In any event, Canada and the European Union have banned its use. A United Nations Food Standard body has not certified its safe use. The hormone is no longer widely used in US.
	3. Food allergies. In 1996, a Brazil nut gene spliced into soybean was reported to induce potentially fatal allergies in people sensitive to Brazil nuts.	The safety assessment confirmed that the protein was an allergen and the development was abandoned. A standard laboratory test has been available to test possible allergenicity in GE products.
	4. Contamination. StarLink, a GE maize variety approved for animal feed but not for human consumption, was found in an ingredient used by some US beer makers and in taco shells in the US in 2000.	The incident was caused by an accidental mix of StarLink with vast amounts of other maize during harvest, storage, and distribution. The contaminated food was recalled and destroyed. A number of quick and cheap tests are available to determine the presence of GM products in food.

Perceived Risks

Table 2 **Summary of Perceived and Genuine Risks of Genetically Engineered Foods and Crops** *(cont'd.)*

Risks	Type of Risk	Remarks
	5. Antibiotic Resistance. Use of an antibiotic marker gene in the development of GE crops may contribute to the growing public health danger of antibiotic resistance.	There is little or no evidence about this risk yet. But this is an emotive topic, and developers have now replaced the antibiotic marker with a safer marker.
Environmental Risks	1. Increased pesticide residues. Farmers growing GE crops will use as many toxic insecticides and herbicides as conventional farmers, thus increasing pesticide residues in soils and on crops.	This risk is not yet proven statistically. There are reports that farmers growing GE crops resistant to pests and herbicides are able to reduce production cost significantly through the reduced use of pesticides. That was a major reason why farmers adopted GE crops widely in the PRC and the US.
	2. Genetic pollution. Wind, rain, birds, and bees have carried genetically altered pollen into adjoining fields, contaminating the DNA of organic, non-GE crops.	This genetic pollution is not an environmental issue unless the transfer of pollens causes some kind of environmental damage. Pollen contamination has taken place for centuries with or without genetic engineering.
	3. Damage to beneficial insects. Scientists from Cornell University found that pollen from Bt maize was poisonous to Monarch butterflies and may be to other beneficial insects as well.	Monitoring systems have been devised in the PRC and the US to evaluate the long-term effect of GE crops on beneficial insects.

Perceived Risks

Table 2 **Summary of Perceived and Genuine Risks of Genetically Engineered Foods and Crops** *(cont'd.)*

Risks	Type of Risk	Remarks
	4. Creation of superweeds. GE crops (soybean and canola) resistant to herbicides may transfer their resistance to weeds, turning them into superweeds, which cannot be controlled by herbicides.	This fear has yet to be proven. Scientists are closely monitoring the use of GE crops resistant to herbicides.
	5. Creation of superpests. GE crops (maize and cotton) resistant to pests may transfer their resistance to pests, turning them into superpests which cannot be controlled by pesticides.	As above, this fear has yet to be proven in practice. There is no known mechanism by which pest resistance from a plant may be transferred to an insect pest.
	6. Creation of new viruses and bacteria. Biotechnology could help terrorists to create killer viruses or bacteria, which could be used in biological weapons.	This could happen, even without biotechnology. Terrorists historically have managed to acquire and subvert beneficial technologies to antisocial purposes.
	7. Genetic bioinvasion. By virtue of their superior genes, some GE plants and animals will inevitably run amok, overpowering wild species in the same way that introduced exotic species do.	There is as yet no scientific evidence that such plants and animals can be created through biotechnology.

Perceived Risks

Table 2 Summary of Perceived and Genuine Risks of Genetically Engineered Foods and Crops *(cont'd.)*

Risks		Type of Risk	Remarks
Socioeconomic Risks	1.	Terminator technology will render seeds infertile and force hundreds of millions of farmers to purchase more expensive GE seeds and chemical inputs from a handful of global biotechnology and seed companies.	The Monsanto Company has withdrawn the terminator gene from its GE crops following many complaints from farmers.
	2.	High concentration of biotechnology research and development in developed countries will widen the income disparity between developed and developing countries, and between large and small farmers.	The public sector in Asia should accord high priority to biotechnology development that address the problems of small farmers.
Ethical Concerns	1.	Biotechnology reduces all life to bits of information (genetic code) that can be rearranged at whim by scientists. The creation of the first genetically modified monkey in 2000 brings the possibility of genetic manipulation closer to humans. There is fear that the technique will be used to create "designer babies."	Although most of these ethical concerns relate to non-agricultural biotechnology, they point to the need for the private sector to incorporate work ethics in biotechnology research and development.
	2.	There seems to be little ethical concern by the private companies over the use of GE animals to produce therapeutic drugs.	

Bt = *bacillus thuringiensis*, DNA = deoxyribonucleic acid, GE = genetically engineered, GM = genetically modified, PRC = People's Republic of China, US = United States.

Source: Skerritt (2000) and Wolfenbargen and Phifer (2000).

Summary of benefits and risks of biotechnology

- The best technology is one that safely gets the job done in the simplest, least risky & inexpensive way possible.
- If managed well, biotechnology could be simple and less expensive for resource poor farmers.
- However, biotechnology should be used for crop improvement in conjunction with other conventional crop improvement techniques.

Summary of benefits and risks of biotechnology

- Research and development (R&D) in crop biotechnology should be encouraged as a means of addressing world food problems.
- In cases where risks to human health and environments seem obvious, further work should be discontinued pending proper re-evaluation and risk assessment.
- Moreover, R&D in biotechnology will advance science and technology and could lead to other innovations beneficial to sustainable agriculture.